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Buzzards Bay Disposal Site
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BUZZARDS BAY DISPOSAL SITE LITERATURE REVIEW

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BUZZARDS BAY DISPOSAL SITE - LITERATURE REVIEW

1.0 INTRODUCTION

The Buzzards Bay Disposal Site, formerly referred to as the Cleveland Ledge Disposal Area, is located approximately 1.4 nautical miles from Chappaquiot Point, West Falmouth, MA. The disposal site consists of a circular area 500 yards in diameter, centered at coordinates 41°36 00N, 70°41 00W, with a depth range of 9-12 meters (Figure 1). The purpose of this report is to summarize environmental conditions at and adjacent to the Buzzards Bay Disposal Site in terms of the potential impacts of continued dredged material disposal. Because of the paucity of literature solely addressing the Buzzards Bay Disposal Site itself, this report includes data gathered throughout Buzzards Bay. In particular, data obtained in or near the Fairhaven Disposal Site and around New Bedford are discussed. The Fairhaven Disposal Site is located on the western side of Buzzards Bay, near the mouth of the Acushnet River (Figure 2). The New Bedford region, in general, has been the focus of recent studies because the upper Acushnet River/New Bedford Harbor region is highly polluted with PCB's and is a potential source of PCB contamination for the entire bay.

Due to its proximity to the oceanographic research community at Woods Hole, MA, Buzzards Bay has been extensively studied. While a majority of these studies are included in the bibliography for this report, only that subset of this large volume of literature bearing directly on the potential impacts of dredged material disposal at the Buzzards Bay Disposal Site are summarized in the text that follows.

2.0 BUZZARDS BAY DISPOSAL HISTORY

The Buzzards Bay Disposal Site has received a wide range of dredged material types. The most recent disposal activities have occurred between February 1979 and November 1985. In the 5 year period from February 1979 to January 1984, an average of 22,500 cubic yards of material have been disposed annually. The sources of this dredged material were small harbor and river channels located throughout the Buzzards Bay region. From September 24, 1985 to November 3, 1985, 73,800 cubic yards from the Mass. Maritime Academy were disposed. The disposal site has not been utilized since November 1985.

3.0 PHYSICAL CONDITIONS

3.1 Physiography of Buzzards Bay

A number of studies of various aspects of the geology

and hydrography of Buzzards Bay have been performed (Peck, 1896; Sumner et al., 1913; Fish, 1925; Hough, 1940; Moore, 1963; Anraku, 1962, 1964; Strahler, 1966; Pearce, 1969; Driscoll, 1975; Rosenfeld et al., 1984). The survey branch of the New England Division (NED) of the Army Corps of Engineers also performed a bathymetric survey of the Buzzards Bay Disposal Site in July 1985. Buzzards Bay lies along the southern boundary of the crystalline bedrock forming the interior Massachusetts lowlands and to the west of the glacial debris-covered insular complex of the Cape Cod-Elizabeth Islands (Figure 2). The long axis of the bay runs northeast-southwest for approximately 46 kilometers from Onset Bay to Penikese Island. At its widest, the Bay is approximately 19.5 kilometers across. The Bay is open to the south and, along part of the eastern boundary, there is appreciable water exchange with Vineyard Sound. There is also some water exchange with Cape Cod Bay through the Cape Cod Canal. Buzzards Bay is relatively shallow, averaging 11 meters in depth. The disposal site is located in the northern half of the Bay and lies within a slight depression, between the 9m (30') and 12m (40') isobaths (Figure 3).

3.2 Sediments

Silt-clay sediments occupy the deeper portions of the Bay. Fine sand occurs in nearshore, depositional areas in the north, while medium sand predominates in southern, nearshore regions. Coarse and medium sands are found in the vicinity of rocky exposures around New Bedford Harbor, off Nasketucket Bay, and along the entire northeast shoal areas of the upper bay (Figure 4). In general, the main portion of the Bay is dominated by two major textural facies. Fine-grained silts occur throughout the deeper portions and troughs, while sands are found in the shallow, higher kinetic energy areas. On the basis of the thickness of fine-grained sediment that has accumulated since the Pleistocene epoch, Hough (1940) estimated an average sedimentation rate of 2.3 mm/yr. More recent radiocarbon dating estimated range from 0.52 to 0.84 mm/yr (Young, 1971).

In the region of the disposal site, a complex topography and mixture of sediment types are evident. Sidescan sonar and REMOTS® sediment-profile surveys were performed to illustrate efficient and cost-effective techniques of mapping the geological and biological properties of the seafloor. The two systems mapped topographic features, sediment texture, and biological successional stages within the Buzzards Bay Disposal Site (Menzie et al., 1982). Six major textural regions were revealed (Figure 5): 1) a disposal mound top, 2) a small wave-like field possibly consisting of large sand waves overlying silt-clay sediments, 3) a cratered bottom, 4) a rubble bottom, 5) an eastern flat bottom, and 6) a western flat bottom. Menzie et al. (1982) interpreted the east and west flat bottom regions to represent ambient seafloor, unaffected by disposal operations. The mound top, a circular region approximately 500 meters across, apparently reflects the center of

prior disposal operations. At the time of the study, it rose to within seven meters of the sea surface. The cratered bottom consisted of circular depressions surrounded by an elevated rim. The authors suggested that these may have been formed by the disposal of sand onto a mud bottom. The rubble field, which occupies most of the region surveyed, represents numerous small topographic highs apparently associated with the wider disposal of dredged material. The "wave field", evident in the sidescan sonar records, is located just north of the disposal mound. The authors could not determine whether it was related to bottom forces (i.e., bedforms) or to disposal operations. If the "wave field" does represent bedforms, a localized high energy region may be present, and fine-grained material deposited in this region may be dispersed. The sand waves may be due to recent storm activity, however sidescan sonar records indicate that this is an isolated area and evidence of sand waves is not seen elsewhere in the Bay.

3.3 Hydrography of Buzzards Bay

Tidal currents are the dominant circulation forces in Buzzards Bay (Figure 6). The dominance of tidal flow results from the island complex to the southeast that protects the Bay from large, long period open ocean waves. Tidal current strength is low (20 cm/sec; 0.4 knots) in the region of the disposal site, when compared to much of the Bay. Complete tidal mixing of Bay water with ocean water is estimated to occur approximately every 10 days. Water temperatures in the Bay range from a summer maximum of 22°C to 0°C in winter. During colder winters, the upper reaches of the Bay often freeze over. Because there are no large streams bringing fresh water into the Bay, the salinity is essentially the same as that of Block Island and Vineyard Sounds, ranging from 29.5 to 32.5 ppt. (Sanders, 1958). Groundwater seepage may represent a significant portion of freshwater inflow (Rosenfeld <u>et</u> <u>al</u>., 1984). A weak and transient thermocline (Figure 7) was present from April to October (Anraku, 1962; Rosenfeld <u>et</u> <u>al</u>., 1984). However, the shallowness of the Bay, combined with surface wave mixing and turbulent tidal flow prevents strong thermal stratification. An extensive hydrographic study of Buzzards Bay was carried out in 1982 and 1983 (Rosenfeld <u>et</u> <u>al</u>., 1984). Overall, the Bay is a tide-dominated, well-mixed estuarine system.

Detailed, seasonal changes in near-bottom hydrographic conditions at four stations located northwest of the Cleveland Ledge channel have been described by Driscoll (1975). Two of these stations were located in nearshore, sandy facies, while two were located in deeper, silt-clay dominated regions (Figure 8). Driscoll concluded that bottom-water dissolved oxygen and pH levels were largely a function of sediment type. Lower dissolved oxygen and pH levels occur over finer-grained, more organic-rich sediments presumably due to higher biochemical and chemical oxygen demand.

3.4 Physical Implications for Dredged Material Disposal

Overall, the Buzzards Bay Disposal Site appears to lie within a relatively low kinetic energy portion of Buzzards Bay. Tidal currents, which represent the strongest physical forces in the Bay, are generally low in the area. Large storm waves are precluded due to the region's physiography and limited fetch. The disposal site is dominated by fine-grained sediments; much of the coarse material (sand and gravel) present apparently represents deposited dredged materials. However, observations indicate some dispersion of disposed materials is possible. The presence of coarse-grained sediments atop the existing disposal mound at Buzzards Bay suggests that scour of fine-grained sediments may occur on shallow topographic features. Bathymetric monitoring of future disposal operations may aid in documenting changes in these topographic features.

4.0 CHEMICAL CHARACTERISTICS

4.1 Water Column

Sanders (1958) noted that dissolved nutrient and chlorophyll levels in Buzzards Bay were significantly lower than levels observed in Long Island Sound. This contrast apparently reflects the relatively small drainage basin which feeds Buzzards Bay. Gilbert et al. (1973) measured nutrients, chlorophyll, and coliform bacteria levels in surface and bottom waters at 14 stations in the Bay during May 1973 (Table 1, Figure 8). Surface water NO_3 levels ranged from 2.24 to 20.45 micrograms/liter with the highest values occurring at the mouth of the Bay northwest of Cuttyhunk Island. Near-bottom NO_3 levels ranged from 0.3 to 25.33 micrograms/liter. Again, relatively high levels were observed at the mouth of the Bay. This pattern may illustrate the influence of organic inputs from the Acushnet River/New Bedford Harbor region. The highest bottom NO_3 concentration was observed in the Fairhaven Disposal Area located near the mouth of the Acushnet River. Chlorophyll levels, both surface and bottom, were generally uniform throughout the Bay, ranging from 1.4 to 4.6 micrograms/liter. Highest levels occurred over the Fairhaven Disposal Area and at the mouth of the Bay. Coliform counts were low (less than 4 counts/100 ml) throughout the Bay, except for the Fairhaven Disposal Area where 14 and 19 coliform counts/100 ml were measured in surface and bottom waters, respectively. The high levels of nutrients and coliform bacteria in waters above the Fairhaven Disposal Area suggest that either disposal operations were taking place around the time of the Gilbert study or other factors such as sewage outfalls or ground seepage may have played a role. Excluding the mouth of the Bay and the Fairhaven site, the distribution of dissolved nutrients and chlorophyll did not show any distinct spatial pattern. In particular, at the two stations (2 and 3, Figure 8) located in and just to the west of the Buzzards Bay

Disposal Site, dissolved nutrients, chlorophyll, and coliform bacteria values reflect the values observed throughout much of the Bay. This pattern reflects the well-mixed nature of the water column.

Gilbert _et_ _al_. (1973) also measured trace metal concentrations (Cu, Zn, Cd, Pb, and Cr) in Buzzards Bay surface and bottom waters (Table 2); these values further illustrate the homogeneous nature of the water column. Elevated levels of trace metals, particularly Cu, Zn, and Cd, were evident only over the Fairhaven Disposal Area. Typical values for the Bay were evident at the two stations located nearest to the Buzzards Bay Disposal Site. The effects of disposal operations at the site on water column chemistry since 1973 are not known. However, the highly-mixed nature of the embayment precludes the establishment of any persistent steep chemical gradients in the water column.

4.2 Sediments

Hough (1940) and Moore (1963) have characterized the mineralogical composition of bottom sediments throughout Buzzards Bay. In large part, deposits reflect the composition of the regional terrigenous material from which the sedimentary materials are derived. Gilbert _et_ _al_. (1973) measured sediment trace metal concentrations at 14 stations (Figure 8, Table 3) approximately corresponding to the stations sampled by Moore (1963). In general, values did not vary widely between the two studies. Station 2, located within the Buzzards Bay Disposal Site, and station 3, located just west of the site, showed metal concentrations that are comparable to the rest of the Bay.

Several studies have documented the levels of organics (e.g. hydrocarbons and PCB's) in bottom sediments of the Bay (Gilbert _et_ _al_., 1973; Sanders, 1974; Summerhayes _et_ _al_., 1977; Teal _et_ _al_., 1978; Sanders _et_ _al_., 1980; Genest and Hatch, 1981; Boehm, 1983). Oil and grease concentrations measured by Gilbert _et_ _al_. (1973) ranged from 80.1 to 377.5 ppm (Table 4). Hydrocarbon concentrations were generally higher in the southern and western portions of the Bay. This likely reflects the influence of New Bedford Harbor. Interestingly, station 2, which was located in the Buzzards Bay Disposal Site and just south of the site of the 1969 West Falmouth oil spill (see Sanders _et_ _al_., 1980), showed the lowest total oil and grease content. It is known, however, that the oil from that spill drifted northeast toward Wild Harbor (Sanders, 1974; Deslauriers and Seeyle, 1977; Schrier and Eidan, 1979; Sanders _et_ _al_., 1980). PCB levels showed increased values near the entrance of New Bedford Harbor. Overall, PCB levels ranged from 0.032 to 0.543 ppm. There was no evidence of PCB enrichment at the stations in or near the Buzzards Bay Disposal Site (Table 4).

The organic content of the fine-grained Buzzards Bay

sediments averages about 2% (Hough, 1940). Gilbert et al. (1973) found that sediment organic content ranged from 0.88% to 6.65% throughout the Bay. Driscoll (1975) found that the mean annual total organic content of the sediment in the northwest portion of the Bay ranged from 0.48 to 3.20% (Table 5). Of this, 0.11 to 0.97% was total organic carbon and 0.026 to 0.147% was total organic nitrogen. The concentration of carbonates ranged from 3.91 to 11.44%. The levels of all three organic parameters are inversely related to grain-size. The carbonate content of the sediment was also generally greater in finer sediments. Minimum organic values occurred in mid-winter, values peaked in late July/early August (Figure 9). Carbonate also peaked in the summer, with a secondary peak occurring in November/December. Driscoll (1975) concluded that these seasonal patterns in sediment organic concentrations were due primarily to changes in the abundance and activity of benthic microorganisms.

4.3 Chemical Implications for Dredged Material Disposal

Given the generally well-mixed nature of the water column in Buzzards Bay, dilution of low-levels of dissolved pollutants seems probable. Excluding the entrance to New Bedford Harbor, sediment-associated contaminants, both metals and organics, show no distinct spatial gradients in the Bay. The only data available for the sites within the Buzzards Bay region are from 1973. Sediment chemistry data from this area subsequent to the disposal occurring from 1979 to 1984 might show elevated contaminant levels depending on the source of the dredged material. However, as indicated by the baywide chemical data as well as the physical data, there was no evidence that contaminants were influencing regions away from the disposal areas (both Buzzards Bay Disposal Site and Fairhaven).

Aspects of bioaccumulation and the introduction of contaminants into commercial species are discussed in section 5.3.

5.0 BIOLOGICAL CHARACTERISTICS

Much of the pioneering work regarding animal-sediment interactions in shallow water marine ecosystems has been carried out in Buzzards Bay. This research has important biological, sedimentological, and disposal management implications. An overview of this extensive literature is presented below.

5.1 Benthos

Sanders (1958, 1960) performed extensive quantitative benthic sampling programs in Buzzards Bay. These data showed that average macrofaunal benthic population densities in Buzzards Bay were 2-4 times less than similar assemblages in Long Island Sound. Low water column nutrient and chlorophyll levels in Buzzards Bay

relative to Long Island Sound suggested that the greater benthic biomass in Long Island Sound was due to larger phytoplankton populations (see section 4.1).

Sanders described two major faunal assemblages from Buzzards Bay: one, present in fine-grained sediments (78-91% silt-clay) was dominated by deposit-feeders, particularly the bivalve Nucula proxima and the polychaete Nephtys incisa; the other, characterized by filter-feeding species of the amphipod genus Ampelisca, was restricted to sandier sediments (Tables 6 and 7).

During the same sampling program, Weiser (1960) characterized the meiofauna of Buzzards Bay. Nematodes and kinorhynchs comprised 89 to 99% of the total meiofauna. A sandy bottom community, characterized by nematodes of the genus Odontophora and Leptonemella, and a muddy bottom community characterized by the nematode Terschellinga longicaudata and three kinorhynch species was recognized.

Subsequent to Sanders' descriptive work, research was carried out to characterize the ecological and sedimentological implications of the community types evident in Buzzards Bay (Rhoads, 1963, 1967, 1973, 1974; Young, 1968, 1971; Rhoads and Young, 1970; Driscoll, 1975; Young and Southard; 1976). Much of this work focused on the effects of the Nucula-Nephtys assemblage on surface sediment properties. For example, Rhoads (1963, 1967) found that relatively low-densities of deposit feeders extensively reworked the top 2-3 cm of the bottom over a two-month period. This biogenic reworking was limited to the top 10 cm of sediment and resulted in biogenically graded deposits, irregular layering, mottling, and fecal pellet layers. This intensive bioturbation is an important agent in the physical diagenesis of marine sediments. Young (1968, 1971) found that the fine-grained facies in Buzzards Bay were characterized by a 2-3 cm surface floccular layer comprised of fecal pellets, organic detritus, plankton, and colloidal mud. This "zone of fecal production" was found to be readily resuspendable (Young and Southard, 1978) and, therefore could be an important mechanism in nutrient exchange between benthic and pelagic ecosystems (Figure 10). Young estimated that between 98.0 and 99.5 % of the top 2-5 cm of deposited sediment in silt-clay facies of Buzzards Bay is resuspended. In a related study, performed immediately south of the Buzzards Bay Disposal Site, Rhoads and Young (1970) concluded that the physical instability of this floccular, fecal surface layer tended to: 1) clog the filtering structures of suspension-feeding organisms, 2) bury newly-settled suspension-feeder larvae, and 3) prevent sessile epifauna from attaching to the unstable mud bottom. This modification of the benthic environment by deposit feeders, resulting in the exclusion of many suspension feeders and sessile epifauna, is an example of "trophic-group amensalism" (Rhoads and Young, 1970).

Evidence that the presence of high near-bottom turbidity is due to the intensive reworking and sediment pelletization by deposit feeders is presented in Rhoads (1974). Following the 1969 West Falmouth oil spill (Sanders et al., 1974, 1980), the mud bottom deposit-feeder community was replaced by surface tube mats of the opportunistic polychaete Capitella and the suspension-feeding, mactrid bivalve Mulinia lateralis. This change in infaunal composition was accompanied by a notable reduction in near-bottom turbidity levels. Prior to the oil spill seasonal turbidity levels ranged between 5 to 10 mg/l, however no turbidity was registered with the transmissometer after the spill (personal communication, D.Rhoads). Following the disappearance of polychaete tube mats and the re-establishment of deposit-feeders, high near-bottom turbidity levels returned.

Driscoll (1975) studied the coupling between infaunal activity, sediments, and bottom waters at four stations in northwest Buzzards Bay. He concluded that sediment microbial activity was correlated with the sediment reworking activity of deposit-feeders. Bioturbation and fecal production enhance microbial populations, which, in turn, increase deposit-feeder abundance. This "microbial gardening" is temperature dependent, therefore distinct seasonal trends in the abundance of sedimentary organic matter, sediment erodibility, and bottom-water pH and dissolved oxygen levels are present (see Figures 9 and 10).

Some information is available on the infaunal community structure within the Buzzards Bay Disposal Site. Menzie et al. (1982) performed a REMOTS® survey of the site based on the six topographic regions identified previously with the sidescan sonar (see Figure 5). The coarse-grained, disposal mound top consisted of an epifaunal community dominated by hydrozoans (Figure 11). All of the sand bottom areas (western flat area, wave field, rubble field) were characterized by low-order successional infauna, i.e., Stage I and II as classified by Rhoads and Germano (1982). The western flat area apparently represented the ambient, sand bottom, suspension-feeding community described by Sanders (1958, 1960). The rubble field (the majority of the area surveyed) appeared to be disturbed by disposal operations. The cratered area exhibited both low-order and high-order successional infauna, indicating a patchy disturbance pattern. Finally, the eastern flat region appeared to be the least disturbed region; it was dominated by high-order successional infauna, i.e., Stage III as classified by Rhoads and Germano (1982). This fine-grained area apparently represented the ambient mud bottom described by Sanders.

5.2 Fish

In the late 1800's, the Massachusetts Division of Marine Fisheries prohibited finfishing in Buzzards Bay by seine, trap, or

trawl in an effort to protect the area as a nursery for commercial fish species (Moss, 1986, personal communication). This ban is still in effect and only hook and line fishing is allowed in Buzzards Bay.

Published literature on fish stocks in Buzzards Bay is rather scarce; a Buzzards Bay finfish database is being compiled by Dr. S.A. Moss at Southeastern Massachusetts University with funding from the EPA. At present, this unfinished database contains approximately 90% of the existing collection of scientific data gathered in the Bay for the last 25 years.

The other known source of unpublished fisheries data is the results of the stock assessment survey carried out by the Massachusetts Division of Marine Fisheries. This is a semi-annual standardized bottom trawl survey program to monitor relative abundance of fish stocks in state territorial waters (a 3 nautical mile wide border extending from the Rhode Island to the New Hampshire boundaries, including Cape Cod Bay and Nantucket Sound). The entire Massachusetts territorial water is divided into 5 regions. These 5 regions are then subdivided into stations that are defined by depth (Figure 12). The data are summarized for the entire 5 region area so that bay-specific information could not be obtained.

As part of the standardized trawling program, 20-minute daytime tows were made along depth contours. General station locations were predetermined by random selections. If a pre-determined site could not be sampled, an alternative site within that depth interval was selected.

In the spring of 1983, some commercially important species (Table 8) were recorded at a higher level of biomass than in 1982; however, the total number of species showed a 9% decrease. In spring of 1984, the biomass of the commercially important species was at a lower level than in 1983, and the biomass for all species decreased 29% from 1981. This represented a decline in coastal fishery resources for the third consecutive year (Howe _et al_., 1985).

In autumn, surveys are typically characterized by low groundfish abundance (due to maximum water temperature) and to large populations of commercially pre-exploitable sized fish (Tables 8 and 9). The autumn surveys of 1983 and 1984 showed sequential decreases in abundance for adults and juveniles for both finfish and groundfish. The 1984 groundfish levels were dramatically lower than those normally encountered. The only species that demonstrated an increase was the black sea bass, with numbers more than 10 times greater the time series average (Howe _et al_., 1985).

The seasonal changes reflected by these data may just

indicate fluctuations in areal distribution and availability and do not necessarily signify changes in population abundance. It also appears that offshore conditions may have delayed the seasonal immigration to shallow waters for some species (Howe et al., 1985). In terms of the Buzzards Bay Disposal Site, it is difficult to make inferences with these data concerning the fish population at or adjacent to the disposal site. The aforementioned data and trends represent the entire region of Massachusetts state territorial waters. A more accurate assessment of impacts to fisheries resources at the Buzzards Bay Disposal Site could be made by employing BRAT (Benthic Remote Assessment Technique) studies in the immediate area.

5.3 Biological Implications for Dredged Material Disposal

If the REMOTS® data obtained at the Buzzards Bay Disposal Site (Menzie et al. 1982) are still accurate, then some aspects of the potential impacts of future disposal operations at this site can be assessed. Past disposal operations at the site appear to have altered the benthic community structure of the region relative to the ambient mud bottom community (hydrozoa and Stages I and II, versus Stage III). As of 1982, however, there was no evidence of any significant impacts immediately to the east or west of the site. This suggests that the benthic disturbance caused by disposal has been limited to the confines of the site.

Disposal of dredged material on areas characterized by the ambient, soft bottom community of Buzzards Bay (e.g., the eastern flat community) would compromise those assemblages. Experiments on the burial of natural assemblages of invertebrates in Buzzards Bay (Nichols et al., 1978) show that most muddy bottom animals can escape burial in 5-10 cm of sediment. However, no infauna can escape depositional layers in excess of 30 cm. As observed in previous DAMOS monitoring programs, surface-dwelling tubicolous polychaetes rapidly recolonize disposal mounds. In Buzzards Bay, these pioneering assemblages will likely be dominated by capitellid polychaetes (Sander et al., 1980). In the absence of further disposal, return to the mature soft bottom community typical of Buzzards Bay will eventually occur. However, because much of the Buzzards Bay Disposal Site has been "disturbed" by past disposal efforts, return to pre-disposal levels (i.e., a Stage I or II community) at the disposal site will probably occur rapidly (less than one year).

Localized disturbance and the associated replacement of deep-dwelling infauna with a near-surface community may enhance secondary productivity (Rhoads et al., 1978). Low-order successional stage, surface-dwelling assemblages are more productive and more readily available to demersal fish than deep-dwelling seres. An important implication of this recolonization pattern at any disposal site and at the Buzzards Bay

Disposal Site is the possibility of making contaminants available to the important commercial fish species by introducing contaminated dredged material to prey benthic species. In order to minimize dredged material disposal impacts, proper use of management techniques such as disposal project evaluations, project sequencing, and disposal site monitoring are imperative.

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Table 1.

Nutrient and Water Quality Data
for Buzzards Bay

S = Surface, B = Bottom (from Gilbert et al., 1973)

WATER QUALITY ANALYSIS RESULTS

Station	Total P mg/l	Chlorophyll ug/l	Coliform Counts/100 ml	NH_3 ppb	NO_3^- ug N/l	NO_2^- ug N/l
1S	.017	2.6	0	161	5.75	2.87
B	.026	4.7	3	154	12.00	4.15
2S	.019	2.3	0	66	7.95	2.55
B	.019	2.7	1	147	10.30	2.55
3S	.020	2.2	1	266	6.05	3.51
B	.026	2.5	0	203	10.92	2.87
4S	.061	1.4	0	77	<0.3	1.67
B	.032	1.5	1	105	<0.3	1.67
5S	.074	4.6	14	60	9.89	1.90
B	.054	4.4	19	65	25.33	2.18
6S	.022	2.5	0	116	5.46	1.27
B	.029	2.8	4	98	6.33	5.11
7S	.058	2.6	0	77	2.58	1.67
B	.054	2.0	1	67	4.86	1.34
8S	.043	1.5	0	77	5.34	1.34
B	.044	1.8	0	63	10.17	2.34
9S	.041	3.1	0	77	6.01	0.67
B	.029	2.2	1	67	8.74	1.34
10S	.057	2.9	1	151	5.16	3.12
B	.024	2.6	1	42	3.42	3.12
11S	.032	2.5	1	56	6.90	3.12
B	.032	1.6	0	55	5.16	3.12
12S	.032	1.8	1	57	2.24	3.43
B	.030	2.3	1	55	3.85	3.12
13S	.074	3.1	1	82	20.45	2.18
B	.038	3.3	0	63	21.28	1.90
14S	.063	3.7	0	119	10.43	1.90
B	.029	3.8	4	37	16.39	1.90

Table 2

Water Column Trace Metal Concentrations in Buzzards Bay
S = Surface, B = Bottom (from Gilbert et al., 1973)

TRACE METALS IN WATER COLUMN
(ppb)

Station	Cu	Zn	Cd	Pb	Cr
1S	12.7	3.3	7.7	0.4	n.d.
B	6.2	16.4	3.2	1.05	2.8
2S	8.6	6.0	9.7	3.2	0.9
B	7.8	20.2	1.80	1.0	n.d.
3S	14.3	11.1	0.9	2.1	n.d.
B	8.6	26.4	0.62	0.9	n.d.
4S	1.44	7.0	0.66	0.9	n.d.
B	2.02	5.8	0.37	10.1	n.d.
5S	7.8	18.1	1.43	2.94	1.0
B	6.0	28.5	1.36	5.6	1.1
6S	1.07	4.32	0.20	2.09	n.d.
B	4.9	29.7	0.21	0.9	n.d.
7S	5.5	14.0	0.175	1.40	n.d.
B	1.3	4.5	1.60	0.64	n.d.
8S	8.8	18.5	1.61	2.55	n.d.
B	3.74	25.8	0.66	1.54	n.d.
9S	7.7	8.4	16.6	1.72	n.d.
B	3.56	11.2	0.61	5.94	0.6
10S	11.1	5.5	0.92	1.07	n.d.
B	1.79	5.4	0.60	0.56	n.d.
11S	9.6	25.4	0.42	1.73	n.d.
B			0.17	1.18	n.d.
12S	11.7	14.5	0.641	1.35	n.d.
B	11.4	16.0	0.43	1.27	n.d.
13S	9.2	9.5	1.04	5.21	0.5
B	5.1	7.9	0.55	4.5	0.7
14S	5.2	6.2	2.81	1.8	3.4
B	6.0	23.2	0.94	6.6	n.d.

n.d. = not detectable

Table 3

Sediment Trace Metal Data for Buzzards Bay.

Values obtained from Moore, 1963 are compared with those obtained from Gilbert et al; 1973. (The data of Gilbert et al. are enclosed in parentheses.) Figure 8 shows the station locations (from Gilbert et al; 1973).

MOORE VS NEA SEDIMENT DATA
(Concentration in ppm)

Sample Moore #	(NEA #)	Cr	Cu	Ni	Pb	V	Zn
31-33	(1)	30 (37)	14 (12)	10 (23)	33 (33)	45 (85)	65 (78)
91	(2)	17 (9)	4.2 (4.2)	6.9 (10)	16.5 (10)	36 (27)	TR (41)
10	(3)	14 (37)	3.5 (12)	5.8 (25)	5.6 (15)	30 (60)	44 (110)
43-44	(4)	34 (26)	4 (8)	22 (15)	56 (16)	80 (32)	64 (37)
25	(6)	52 (41)	15 (13)	19.6 (31)	28.5 (29)	66 (66)	46 (122)
66	(7)	71 (36)	22 (14)	25.7 (27)	82.3 (31)	72 (71)	63 (81)
73	(8)	21 (34)	4.9 (16)	5.6 (23)	16.5 (32)	32 (48)	TR (76)
71	(9)	25 (23)	5.1 (8)	9.5 (13)	14.5 (21)	43 (40)	72 (50)
119	(10)	64 (40)	15.5 (13)	24 (27)	58 (27)	70 (59)	ND (82)
81	(11)	35 (32)	8 (10)	8.7 (17)	26.3 (21)	43 (35)	TR (66)
84	(12)	16 (39)	1.6 (15)	3.5 (27)	14.0 (32)	26 (46)	31 (127)
132	(13)	41 (11)	7 (4.5)	13.4 (6)	31.5 (14)	52 (25)	55 (58)

TR- trace
ND- not determined

Table 4

The Organic Matter Values in
Sediments of Buzzards Bay
(from Gilbert et al., 1973)
Figure 8 Shows the Sample Locations.

ORGANIC MATTER IN SEDIMENTS

Station	Oil & Grease (ppm dry weight)	Polychlorinated Biphenyls (ppm dry Wt.)	Organic Content (% dry Wt.)
1	88.6	0.032	6.65
2	80.1	0.113	1.58
3	90.3	0.034	1.81
4	197.9	0.274	4.54
5	110.4	0.543	3.65
6	91.4	0.226	6.72
7	157.3	0.406	6.82
8	239.8	0.077	2.39
9	226.7	0.201	4.82
10	377.5	0.175	6.13
11	159.8	0.222	5.30
12	207.4	0.242	5.81
13	620.8	0.072	1.52
14	81.4	0.079	0.88

Table 5

Various Sedimentary, Physical and Chemical Parameters at Four Stations in Buzzards Bay, MA (from Driscoll, 1975)

	Station Number			
	1	2	3	4
Mean Grain Diameter (phi)	0.91	3.38	1.66	4.26
Standard Deviation of Grain Diameter	1.45	1.37	0.94	0.96
Mean Annual Total Organics (%)	0.48	2.20	0.58	3.20
	(0.14)	(0.49)	(0.16)	(0.65)
Mean Annual Organic Carbon (%)	0.11	0.90	0.13	0.97
	(0.08)	(0.30)	(0.05)	(0.24)
Mean Annual Nitrogen (%)	0.027	0.060	0.026	0.147
	(0.027)	(0.022)	(0.023)	(0.019)
Mean Annual Carbonate (%)	3.91	6.61	4.12	11.44
	(0.90)	(1.81)	(1.00)	(2.04)
Depth (m)	4.6	0.9	7.0	12.5
Mean Annual Dissolved Oxygen (mgl^{-1})	9.18	9.20	8.66	8.33
	(0.08)	(0.06)	(0.05)	(0.09)
Mean Annual pH	7.91	7.87	7.89	7.84
	(0.08)	(0.09)	(0.02)	(0.07)

Table 6

Dominant Infauna of a
Soft-Bottom Community (after Sanders, 1958)

Species	Percent Composition
Polychaeta	
Nephtys incisa	17.13
Nerinides sp.	6.85
Ninoe nigripes	3.01
Lumbrinereis tenuis	1.52
Tharyx acutus	1.08
Crustacea	
Ampelisca spinipes	2.92
Unciola irrorata	1.85
Lamellibranchia	
Nucula proxima	23.83
Cerastoderma sp.	2.69
Pitar morrhuana	2.55
Gastropoda	
Turbonilla sp.	9.21
Retusa canaliculata	6.00
Cylichna orzya	4.56

Table 7

The Dominant Infauna of a
Sand-Bottom Community (after Sanders, 1958)

Species	Percent Composition
Polychaeta	
Glycera americana	5.47
Nephtys bucera	4.47
Ninoe nigripes	2.97
Lumbrinereis tenuis	2.69
Nephtys incisa	1.99
Crustacea	
Ampelisca spinipes	18.59
Byblis serrata	11.31
Ampelisca macrocephala	6.31
Unciola irrorata	1.65
Lamellibranchia	
Cerastoderma pinnulatum	10.17
Tellina tenera	3.29
Tunicata	
Molgula complanata?	1.85

Table 8

Weight (kilograms) and Number for Fish and Shellfish Species Collected during the 1983 Spring and Autumn Bottom Trawl Surveys, Massachusetts Territorial Waters. The Asterisk indicates some of the Commercially Important Species (from Howe et al; 1985).

	Spring		Autumn	
Species	Wt.	No.	Wt.	No.
Ocean pout	4,886.7	6,228	169.0	951
Northern searobin	4,289.6	25,543	69.3	1,404
Winter skate	2,526.8	1,739	1,486.8	1,106
Winter flounder*	2,197.9	7,565	778.4	3,647
Little skate	1,001.4	1,709	944.3	1,885
Atlantic cod*	867.9	2,686	4.7	77
Windowpane	704.3	2,299	92.5	470
Longhorn sculpin	538.1	3,534	63.9	794
American plaice	438.1	2,772	222.0	4,054
Tautog	435.6	251	24.5	90
Yellowtail flounder	397.2	1,227	164.8	1,076
Spider crab	364.4	4,595	69.4	1,047
Longfin squid*	358.4	4,500	288.2	39,818
Spiny dogfish	316.7	81	4,891.3	1,816
Red hake	307.0	1,333	633.2	2,715
Silver hake	257.0	2,106	185.6	1,917
Scup*	175.5	1,262	1,174.6	140,003
Summer flounder	117.5	115	83.0	71
Rock crab	93.9	738	456.3	5,782
Atlantic herring	84.6	2,106	63.5	743
Black sea bass*	75.8	235	50.8	8,933
Sea raven	72.8	82	12.3	52
American lobster	70.0	208	350.9	1,364
Moonsnail (unclassified)	69.1	691	34.1	336
Goosefish	64.3	12	94.6	19
Smooth dogfish	60.1	18	297.9	409
Pollock	49.0	502	2.1	8
Fourspot flounder	48.0	243	58.7	359
Witch flounder	47.8	102	69.9	110
Alewife	40.7	1,350	18.6	176
Atlantic wolffish	39.8	17	6.2	2
Haddock	27.1	126	0.9	36
Knobbed whelk	22.7	50	98.0	201
Thorny skate	21.9	19	61.6	72
Cunner	17.1	147	3.0	116
American sand lance	15.2	2,030	0.0	3
Butterfish	11.7	113	229.4	20,809
Snakeblenny	11.7	183	9.5	257
Fourbeard rockling	10.2	190	11.3	119
Blueback herring	9.2	586	1.1	22
White hake	9.1	107	27.8	137
Horseshoe crab	7.9	8	24.9	24
Lady crab	7.5	82	74.5	1,958
Striped searobin	7.3	19	3.3	23
Channeled whelk	5.2	16	14.8	64

Table 8 (continued)

Species	Spring Wt.	Spring No.	Autumn Wt.	Autumn No.
Sea scallop	3.1	12	18.0	313
Daubed shanny	3.0	516	0.2	42
Jonah crab	2.6	20	43.4	220
Atlantic mackerel	2.3	3	-	-
Rainbow smelt	2.0	73	0.6	30
American shad	2.0	37	2.2	17
Mussel (unclassified)	1.5	8	17.3	51,233
Conger eel	1.3	1	-	-
Redfish	1.0	8	0.2	1
Bay scallop	0.5	10	10.5	121
Ocean quahog	0.4	2	0.3	2
Shortfin squid	0.2	1	3.4	21
Spotted hake	0.1	8	1.4	12
Alligatorfish	0.0	10	0.3	107
Rock gunnel	0.0	6	0.0	11
Northern pipefish	0.0	2	0.2	186
Atlantic tomcod	0.0	1	-	-
Mailed sculpin	0.0	1	0.0	1
Torpedo ray	-	-	50.0	2
Wrymouth	-	-	5.9	5
Bluefish	-	-	5.2	25
Surf clam	-	-	3.7	7
Mackerel scad	-	-	1.8	281
Hogchoker	-	-	1.2	11
Weakfish	-	-	0.8	48
Gray triggerfish	-	-	0.7	1
Northern stonecrab	-	-	0.6	1
Round herring	-	-	0.5	8
Menhaden	-	-	0.5	2
Northern puffer	-	-	0.4	88
Gulf Stream flounder	-	-	0.3	4
Fawn cusk eel	-	-	0.2	10
Octopus (unclassified)	-	-	0.2	3
Blue crab	-	-	0.2	2
Oyster toadfish	-	-	0.2	1
Bay anchovy	-	-	0.1	75
Striped anchovy	-	-	0.1	39
Atlantic moonfish	-	-	0.1	13
Atlantic silversides	-	-	0.1	3
Northern kingfish	-	-	0.1	1
Blue runner	-	-	0.1	1
Snowy grouper	-	-	0.0	8
Short bigeye	-	-	0.0	4
Lumpfish	-	-	0.0	3
Guaguanche	-	-	0.0	2
Radiated shanny	-	-	0.0	1
Planehead filefish	-	-	0.0	1
Seasnail	-	-	0.0	1
TOTAL	21,200.0	80,264	13,592.7	298,013

Table 9

Weight (kilograms) and Number for Fish and Shellfish Species Collected during the 1984 Spring and Autumn Bottom Trawl Surveys, Massachusetts Territorial Waters. The Asterisk Indicates Some of the Commercially Important Species (from Howe et al; 1985).

Species	Spring		Autumn	
	Wt.	No.	Wt.	No.
Ocean pout	4,447.8	7,674	59.9	178
Winter skate	4,243.9	2,859	1,425.1	685
Winter flounder*	1,494.3	4,983	565.9	1,890
Spiny dogfish	1,190.9	657	21,631.0	12,730
Tautog	989.7	677	99.3	75
Little skate	985.5	1,765	758.1	1,283
Longhorn sculpin	634.9	5,032	49.6	461
Silver hake	457.4	2,613	135.0	838
Windowpane	389.9	1,309	72.3	318
Yellowtail flounder	377.2	1,494	57.1	320
Atlantic cod*	370.3	619	6.5	489
Northern searobin	366.5	1,627	68.2	522
Scup*	343.9	890	1,102.7	86,922
American plaice	272.5	2,946	119.4	1,158
Longfin squid*	232.5	3,314	182.8	13,510
Red hake	224.2	1,051	265.5	845
Sea Raven	107.5	105	20.6	39
American lobster	106.0	338	324.7	1,647
Goosefish	78.8	14	116.9	25
Rock crab	76.4	516	249.0	2,065
Sand lance	69.1	6,426	.5	84
Smooth dogfish	65.6	20	395.2	718
Fourspot flounder	65.3	318	26.4	148
Atlantic herring	56.6	1,107	76.8	646
Moonsnail	53.5	525	74.5	675
Spider crab	47.1	267	30.0	322
Witch flounder	41.6	72	14.7	23
Alewife	40.0	851	9.3	151
Summer flounder	38.8	30	80.5	83
Black sea bass*	35.6	84	80.4	10,219
Wolffish	35.4	7	--	--
Snakeblenny	35.4	784	.4	15
Butterfish	26.5	256	137.7	7,188
Cunner	16.1	115	2.2	53
Channeled whelk	15.6	60	17.8	62
Sea scallop	15.1	50	22.6	161
Haddock	14.1	17	.2	1
Knobbed whelk	11.8	34	20.4	42
Thorny skate	9.3	24	21.5	20
Horseshoe crab	8.3	5	29.9	21
Blueback herring	7.5	285	1.0	26
Mackerel	6.8	8	--	--

Table 9 (Continued)

Species	Spring		Autumn	
	Wt.	No.	Wt.	No.
Mussel, unclassified	5.7	40	3.4	54
White hake	4.7	92	4.7	51
Lumpfish	4.0	1	.0	1
Daubed shanny	3.7	606	.0	15
Lady crab	3.2	31	51.9	859
Fourbeard rockling	2.6	35	1.4	26
Jonah crab	1.7	10	27.6	174
Ocean quahog	1.6	8	3.7	16
Wrymouth	1.5	1	6.1	5
American shad	1.5	16	.9	10
Striped searobin	1.5	3	3.4	15
Surf clam	1.1	4	.2	2
Pollock	.8	7	.1	1
Bay scallop	.6	9	1.6	21
Oyster toadfish	.6	1	--	--
Quahog	.4	2	.1	1
Menhaden	.3	1	.2	1
Atlantic tomcod	.2	1	--	--
Alligatorfish	.1	36	.0	1
Blue crab	.1	1	1.7	7
Grubby	.0	1	--	--
Rock gunnel	.0	9	--	--
Pipefish	.0	1	.0	7
American eel	.0	1	--	--
Gulfstream flounder	.0	1	.0	3
Octopus, unclassified	.0	3	--	--
Rainbow smelt	.0	2	.3	7
Bluefish	--	--	24.4	136
Atlantic torpedo	--	--	20.2	1
Spotted hake	--	--	1.9	14
Hogchoker	--	--	1.3	6
Northern kingfish	--	--	1.3	10
Rough scad	--	--	1.0	31
Shortfin squid	--	--	.9	11
Round herring	--	--	.8	15
Mackerel scad	--	--	.7	136
Atlantic moonfish	--	--	.3	32
Northern puffer	--	--	.3	20
Banded rudderfish	--	--	.3	1
Short bigeye	--	--	.3	14
Striped anchovy	--	--	.2	104
Bigeye	--	--	.1	6
Bigeye scad	--	--	.1	1
Guaguanche	--	--	.1	5
Weakfish	--	--	.0	8
Moustache sculpin	--	--	.0	1
Red goatfish	--	--	.0	1
Planehead filefish	--	--	.0	4
Total	18,141.1	52,751	28,513.1	148,972

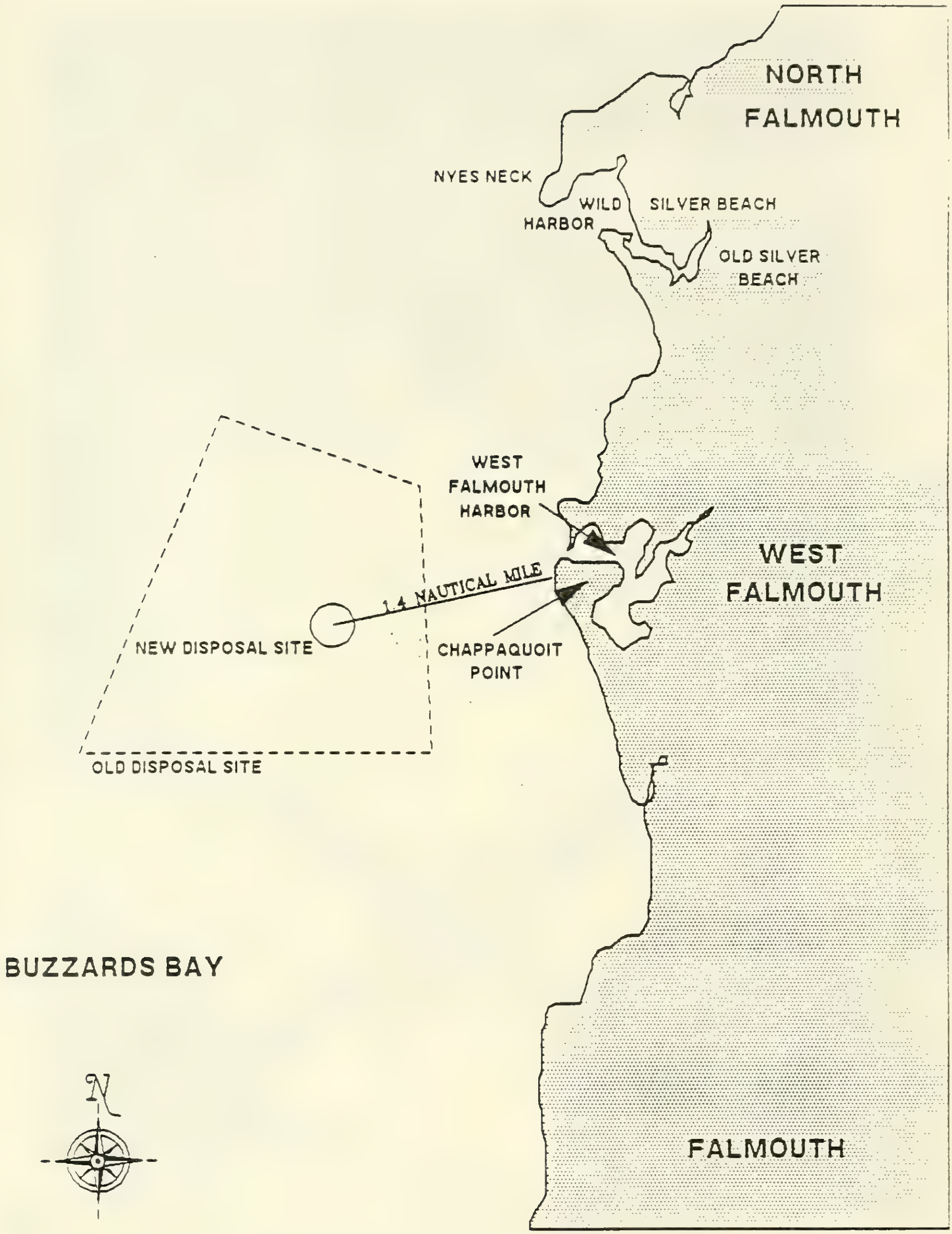

Figure 1. The Buzzards Bay Disposal Site, Buzzards Bay, MA.

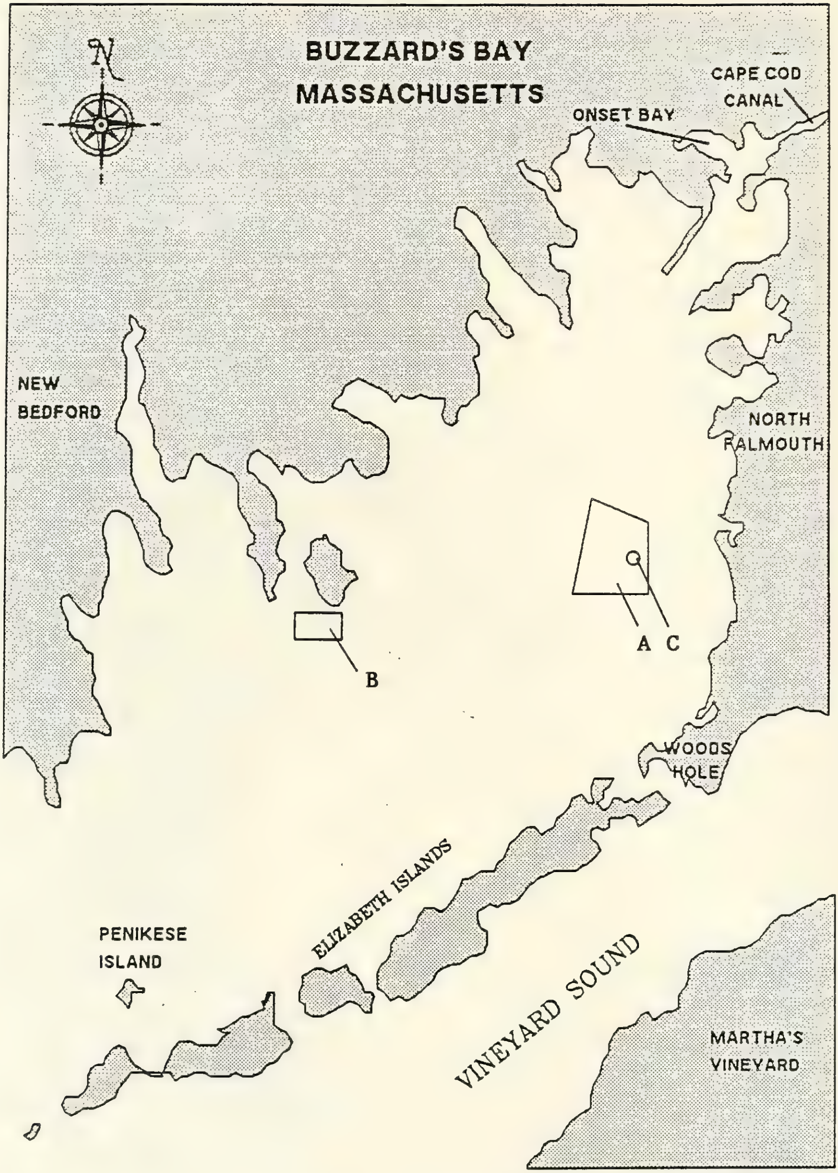

Figure 2. Disposal Area Locations in Buzzards Bay, Massachusetts. Site A is the old Cleveland Ledge Disposal Site, Site B is the Fairhaven Disposal Area and Site C is the Buzzards Bay Disposal Site.

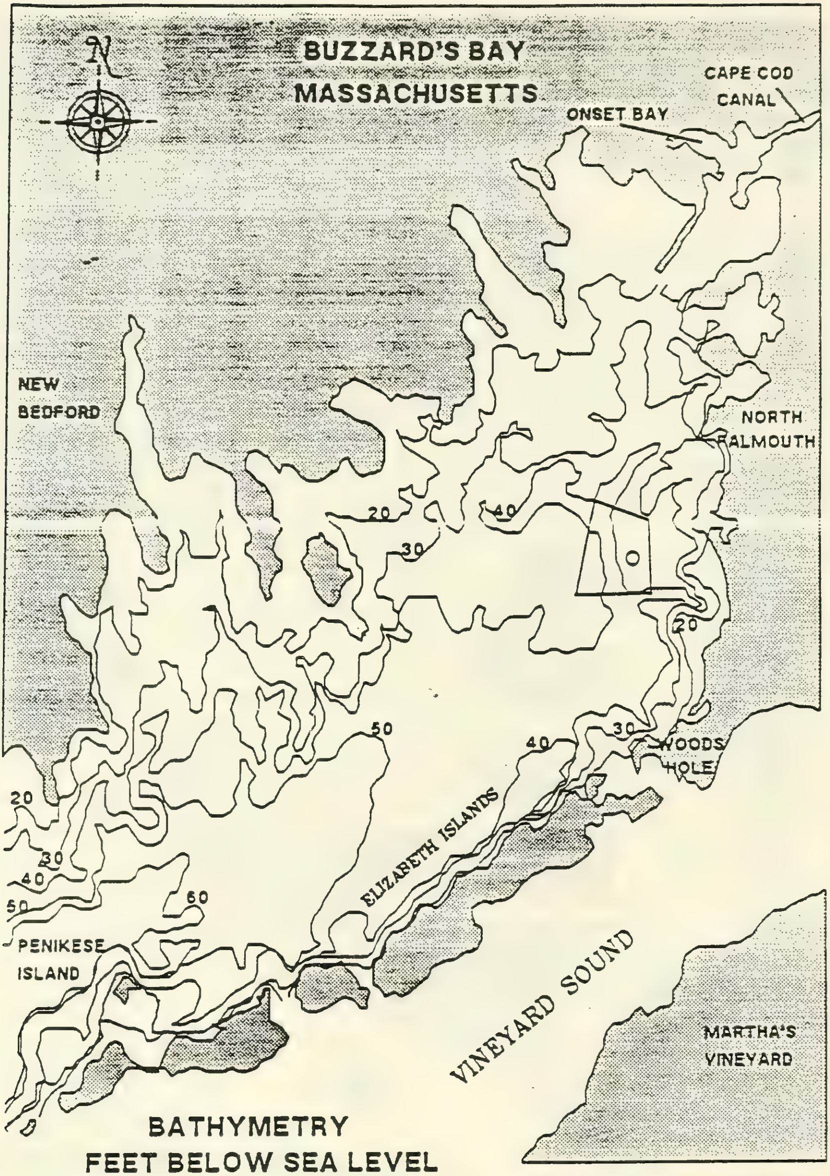

Figure 3. Buzzards Bay bathymetry chart (from Moore, 1963).

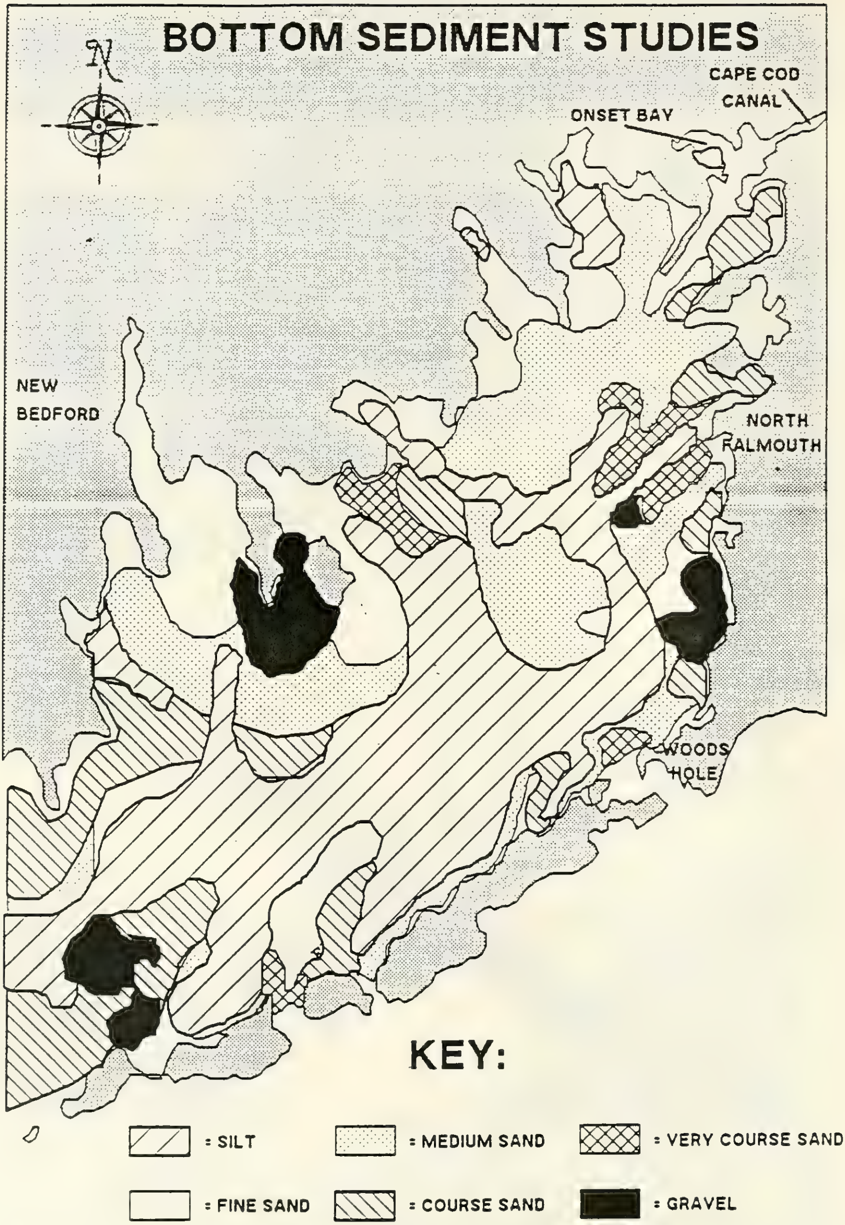

Figure 4. Buzzards Bay sediment distribution map based upon data taken from x-ray diffraction, petrographic and chemical studies (from Moore, 1963).

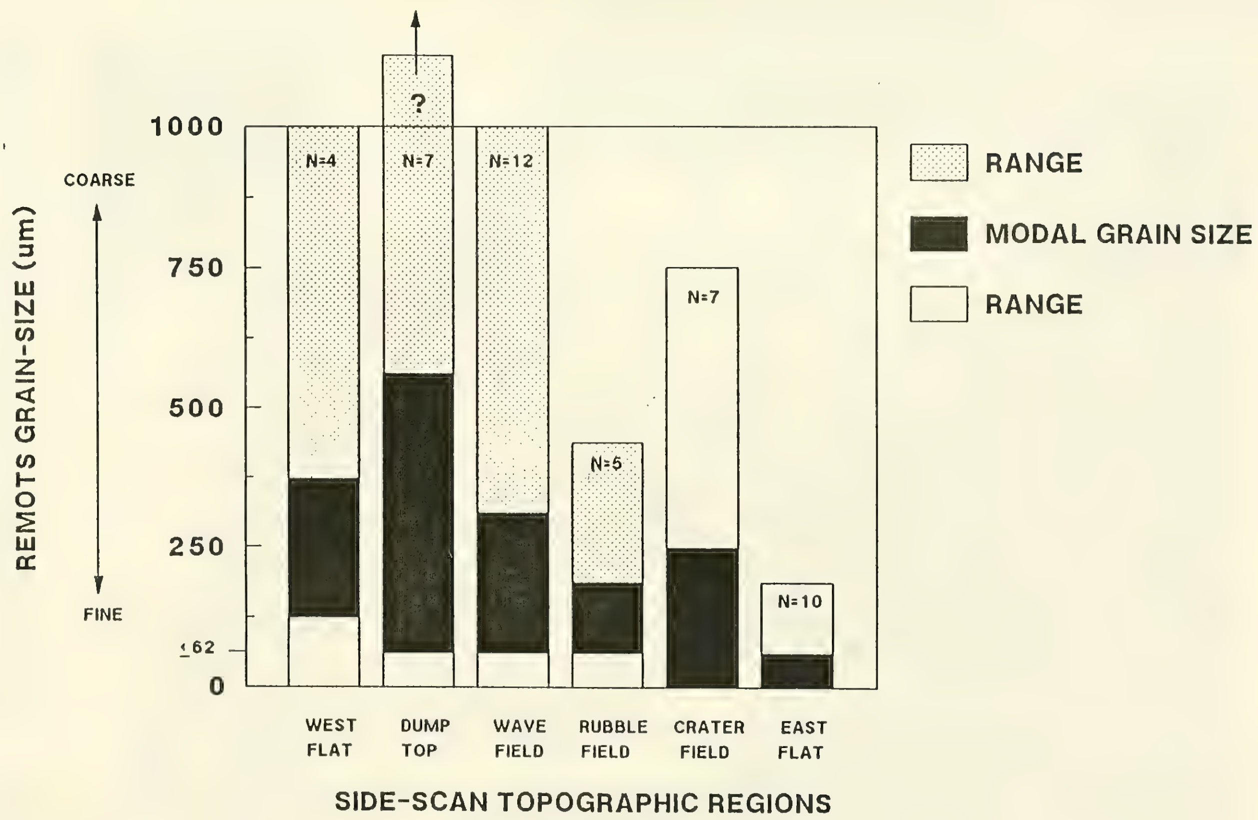

Figure 5. Visual grain measurements (major mode and range) obtained from REMOTS® photographs for each topographic region (Menzie et al; 1982).

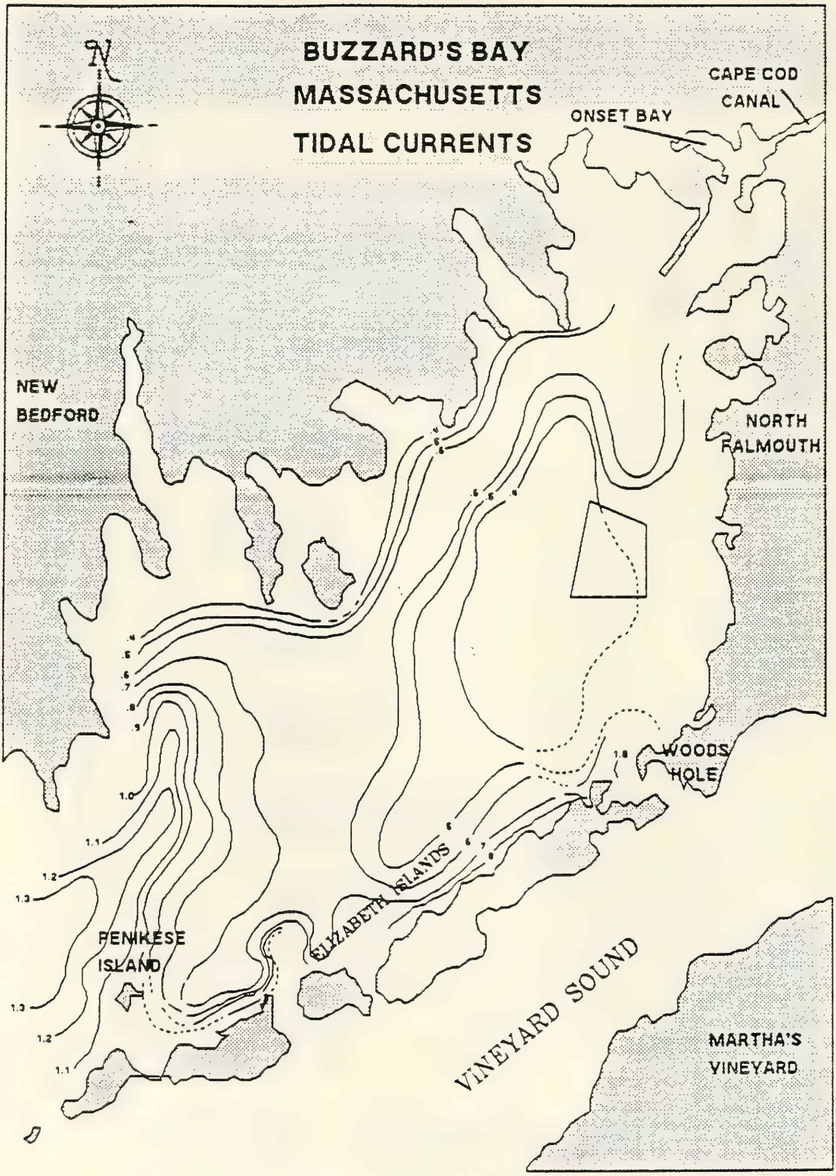

Figure 6. Tidal currents in Buzzards Bay (from Moore, 1963).

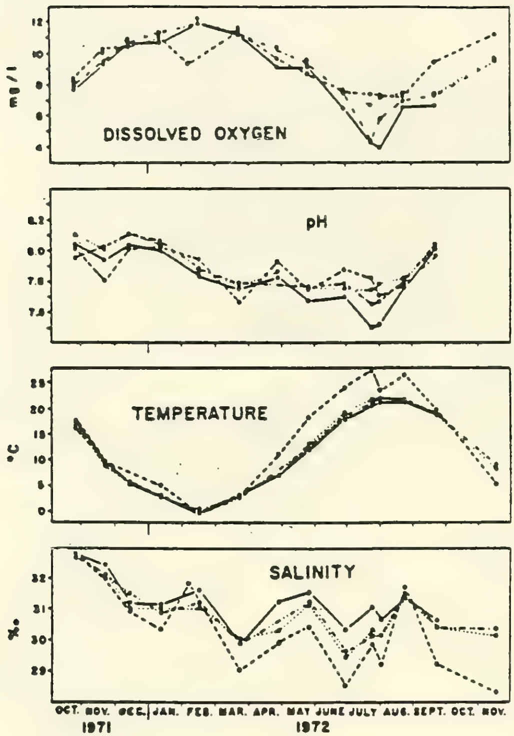

Figure 7. Bottom water characteristics at four stations in northwestern Buzzards Bay from October, 1971 to November, 1972. Dashes indicate sta.2 (depth - 0.9m); dots indicate sta.1 (depth - 5.6m); dots and dashes indicate sta.3 (depth - 7.0m); solid line indicates sta.4 (depth - 12.5m) (from Driscoll, 1975).

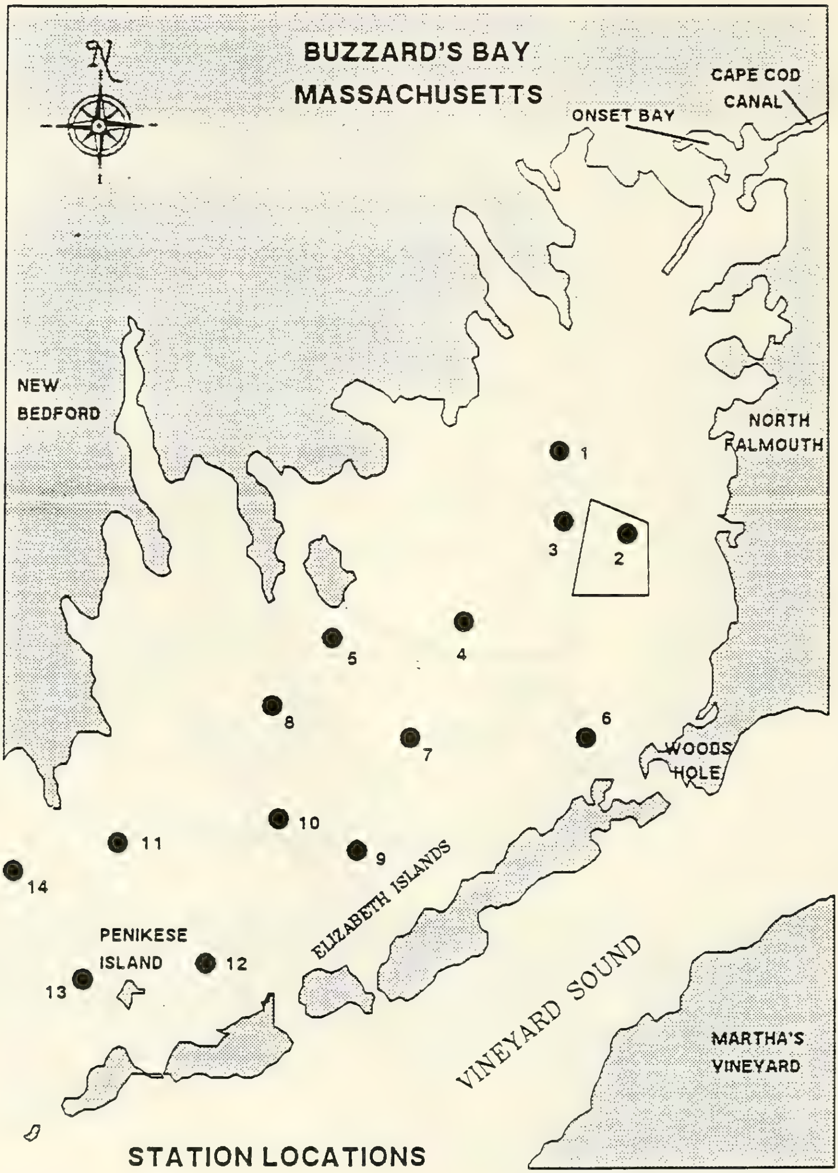

Figure 8. Station locations from Gilbert et al. (1973). Surface and bottom water nutrients, chlorophyll and coliform levels were measured in May 1973. See Tables 1-4 for associated data.

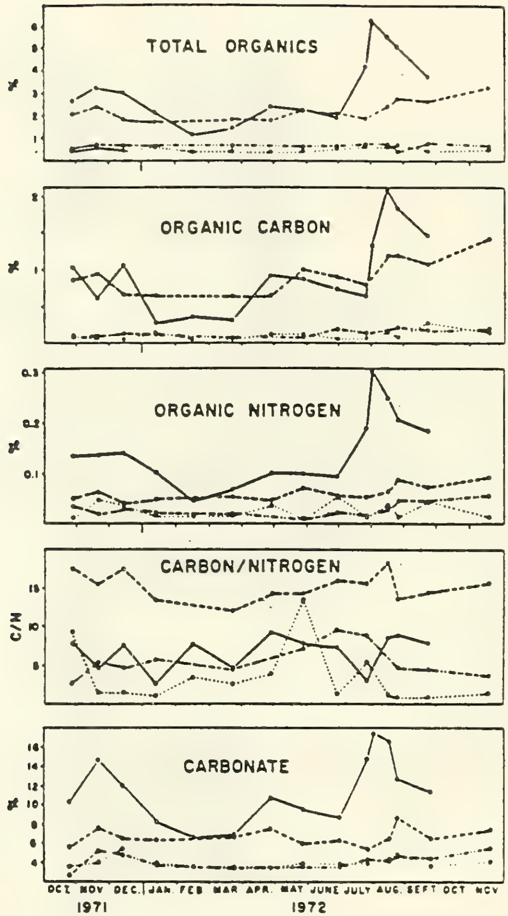

Figure 9. Sediment characteristics at four stations in northwestern Buzzards Bay from October, 1971 to November, 1972. Dashes indicate sta. 2 (depth - 0.9m); dots indicate sta. 1 (depth - 5.6m); dots and dashes indicate sta. 3 (depth - 7.0m); solid line indicates sta. 4 (depth - 12.5m) (from Driscoll,1975).

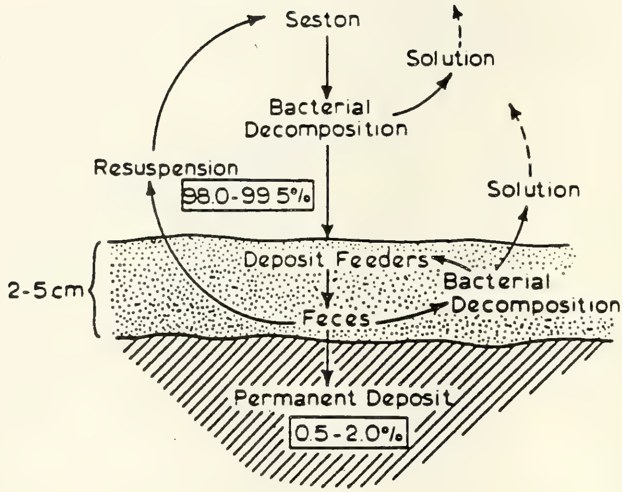

Figure 10. The deposition / resuspension cycle characteristic of a soft-bottom deposit feeding community (from Young, 1971).

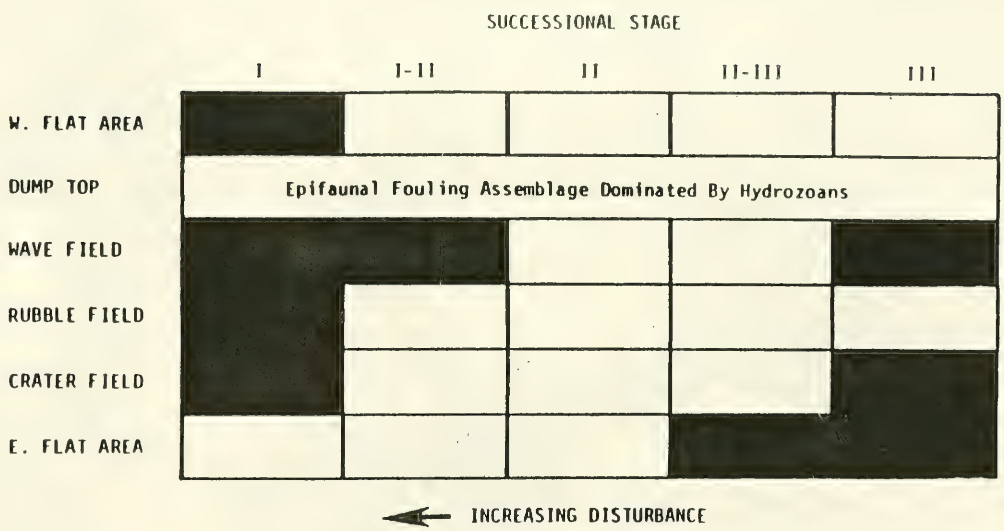

Figure 11. Dominant infaunal successional stages at each topographic area indicated in Figure 5. (See text for further discussion.) (from Menzie et al; 1982).

Figure 12. Sampling area and stations used in Massachusetts Division of Marine Fisheries inshore bottom trawl survey. Region 1 of the 5 regions encompasses Buzzards Bay, Vineyard Sound and coastal waters south of Martha's Vineyard (from Howe et al; 1985).

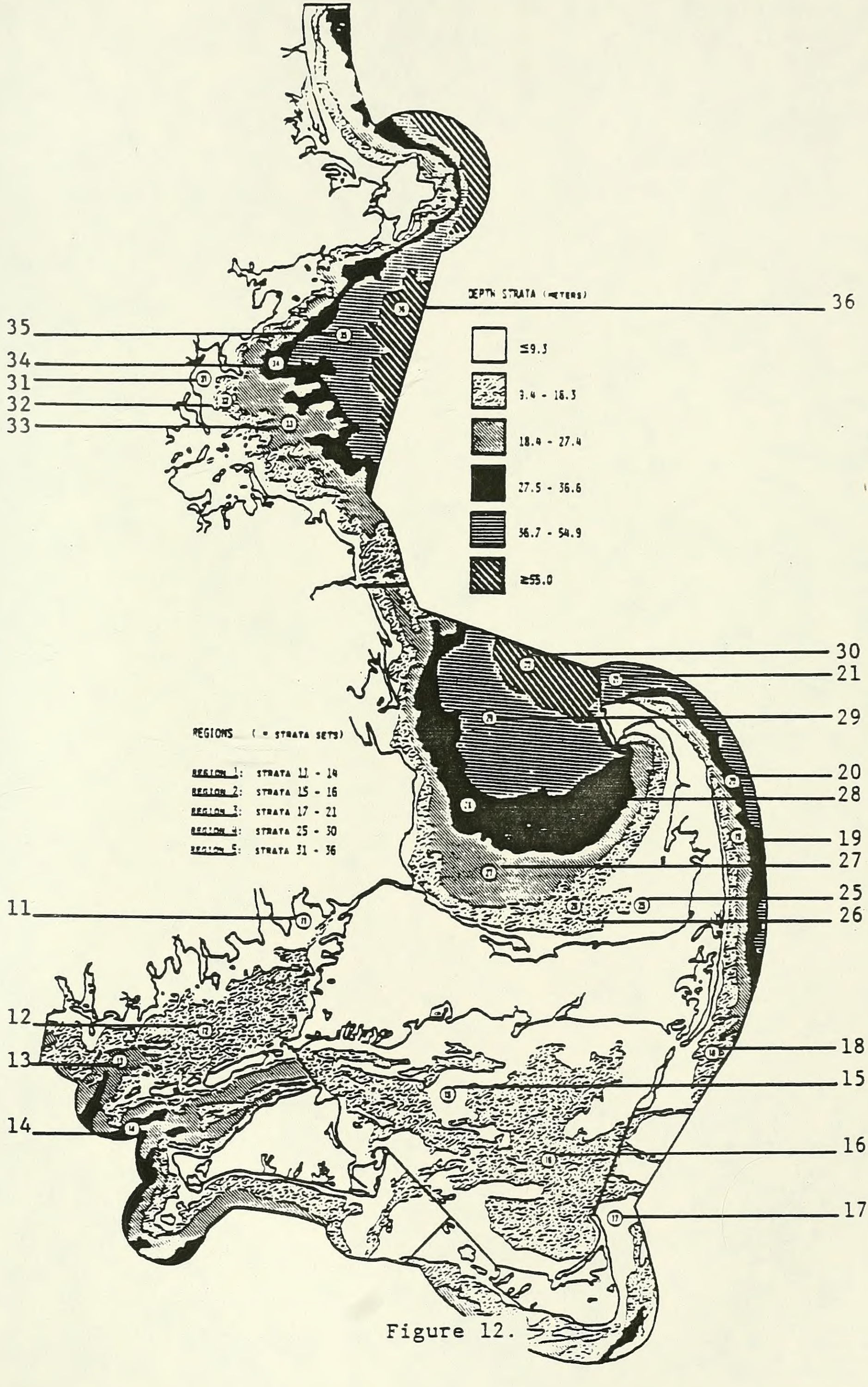
DEPTH STRATA (METERS)
≤9.3
3.4 - 18.3
18.4 - 27.4
27.5 - 36.6
36.7 - 54.9
≥55.0
REGIONS (= STRATA SETS)
REGION 1: STRATA 11 - 14
REGION 2: STRATA 15 - 16
REGION 3: STRATA 17 - 21
REGION 4: STRATA 25 - 30
REGION 5: STRATA 31 - 36
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Figure 12.